METHOD AND SYSTEM FOR CAUSE-EFFECT TIME LAPSE ANALYSIS

Background of Invention

[0001] Well logs are measurements, typically with respect to depth, of selected physical parameters of earth formations penetrated by a wellbore. Well logs are typically recorded by inserting various types of measurement instruments disposed on an integrated measurement platform into a wellbore, moving the instruments along the wellbore, and recording the measurements made by the instruments. One type of well log recording includes lowering the instruments at the end of an armored electrical cable, and recording the measurements made with respect to the length of the cable extended into the wellbore. Depth within the wellbore is inferred from the extended length of the cable. Recordings made in this way are substantially directly correlated to measurement depth within the wellbore. Other methods for measurement include a "logging while drilling" (LWD) method, a "measurement while drilling" (MWD) method, and a memory logging method. The LWD method involves attaching the instruments to the lower portion of a drilling tool assembly used to drill the wellbore. LWD and wireline tools are typically used to measure the same sorts of formation parameters, such as density, resistivity, gamma ray, neutron porosity, sigma, ultrasonic measurement, etc. MWD tools are typically used to measure parameters closely associated with drilling, such as well deviation, well azimuth, weight-on-bit, mud flowrate, annular borehole pressure, etc. Document US 6,272,434 illustrates this technology.

[0002] The aforementioned well logging tools may be conveyed into and out of a well via wireline cable, drilling pipe, coiled tubing, slickline, etc. Further, LWD and MWD measurement methods allow for measurement in the drill string while

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Claims

[c1] A method of evaluating changes for a wellbore interval, comprising:

obtaining first log data acquired by a logging sensor (8, 5, 6, 3) during a first pass over the wellbore interval;

obtaining second log data at a time later than the first log data, said second log data being acquired by the logging sensor during a second pass over the wellbore interval;

calculating a plurality of delta values between the first log data and the second log data;

deriving an observed effect using the plurality of the delta values; and

identifying a correlation between the observed effect and a causal event.

[c2] The method of claim 1, further comprising displaying the correlation on a display device (82).

[c3] The method of any of claims 1-2, wherein the logging sensor measures at least one parameter selected from the group consisting of gamma ray, resistivity, neutron porosity, density, ultrasonic caliper, and sigma.

[c4] The method of any of claims 1-3, wherein the logging sensor is disposed on an integrated measurement tool.

[c5] The method of any of claims 1-4, wherein the correlation is a depth correlation.

[c6] The method of any of claims 1-5, wherein the correlation is a time correlation.

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[c7] The method of claim 1, further comprising:

calculating a relative effect using a sensitivity factor to adjust the correlation; and

displaying the correlation and the relative effect on a display device (82).

[c8] A system for evaluating changes for a wellbore interval comprising:

a well log data acquisition system (7) for acquiring first log data and second log data, at a time later than said first log data, from a logging sensor (8, 5, 6, 3) during a plurality of passes over the wellbore interval; and

a well log data processing system (72,74, 76) for:

calculating a plurality of delta values between the first log data and the second log data;

deriving an observed effect using the plurality of the delta values; and

identifying a correlation between the observed effect and a causal event.

[c9] The system of claim 8, further comprising a display device (82) for displaying the correlation.

[c10] The system of any of claims 8-9, wherein the logging sensor measures at least one parameter selected from the group consisting of gamma ray, resistivity, neutron porosity, density, ultrasonic caliper, and sigma.

[c11] The system of any of claims 8-10, wherein the logging sensor is disposed on an integrated measurement tool.

[c12] The system of any of claims 8-11, wherein the correlation is a depth correlation.

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[c13] The system of any of claims 8-12, wherein the correlation is a time correlation.

[c14] The system of claim 8, further comprising a well log data processing system (72, 74, 76) for calculating a relative effect using a sensitivity factor to adjust the correlation; and displaying the correlation and the relative effect on a display device.

[c15] A computer system for evaluating changes for a wellbore interval, comprising:

a processor (72);

a memory (74);

a storage device (76);

a computer display (82); and

software instructions stored in the memory for enabling the computer system under control of the processor, to perform:

gathering first log data from a logging sensor during a first pass over the wellbore interval;

gathering second log data, at a time later than said first log data, from the logging sensor during a second pass over the wellbore interval;

calculating a plurality of delta values between the first log data and the second log data;

deriving an observed effect using the plurality of the delta values;

identifying a correlation between the observed effect and a causal event; and

displaying the correlation on the computer display.

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Background of Invention

[0001] Well logs are measurements, typically with respect to depth, of selected physical parameters of earth formations penetrated by a wellbore. Well logs are typically recorded by inserting various types of measurement instruments disposed on an integrated measurement platform into a wellbore, moving the instruments along the wellbore, and recording the measurements made by the instruments. One type of well log recording includes lowering the instruments at the end of an armored electrical cable, and recording the measurements made with respect to the length of the cable extended into the wellbore. Depth within the wellbore is inferred from the extended length of the cable. Recordings made in this way are substantially directly correlated to measurement depth within the wellbore. Other methods for measurement include a "logging while drilling" (LWD) method, a "measurement while drilling" (MWD) method, and a memory logging method. The LWD method involves attaching the instruments to the lower portion of a drilling tool assembly used to drill the wellbore. LWD and wireline tools are typically used to measure the same sorts of formation parameters, such as density, resistivity, gamma ray, neutron porosity, sigma, ultrasonic measurement, etc. MWD tools are typically used to measure parameters closely associated with drilling, such as well deviation, well azimuth, weight-on-bit, mud flowrate, annular borehole pressure, etc.

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replaced by Article 34

Claims

[c1] A method of evaluating changes for a wellbore interval, comprising:

obtaining first log data acquired by a logging sensor during a first pass over the wellbore interval;

obtaining second log data acquired by the logging sensor during a second pass over the wellbore interval;

calculating a plurality of delta values between the first log data and the second log data;

deriving an observed effect using the plurality of the delta values; and

identifying a correlation between the observed effect and a causal event.

[c2] The method of claim 1, further comprising displaying the correlation on a display device.

[c3] The method of claim 1 or 2, wherein the second log data is acquired at a time later than the first log data.

[c4] The method of any of claims 1-3, wherein the logging sensor measures at least one parameter selected from the group consisting of gamma ray, resistivity, neutron porosity, density, ultrasonic caliper, and sigma.

[c5] The method of any of claims 1-4, wherein the logging sensor is disposed on an integrated measurement tool.

[c6] The method of any of claims 1-5, wherein the correlation is a depth correlation.

[c7] The method of any of claims 1-6, wherein the correlation is a time correlation.

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[c8] The method of claim 1, further comprising:
calculating a relative effect using a sensitivity factor to adjust the correlation; and
displaying the correlation and the relative effect on a display device.

[c9] A system for evaluating changes for a wellbore interval comprising:
a well log data acquisition system for acquiring first log data and second log data from a logging sensor during a plurality of passes over the wellbore interval; and
a well log data processing system for:
calculating a plurality of delta values between the first log data and the second log data;
deriving an observed effect using the plurality of the delta values; and
identifying a correlation between the observed effect and a causal event.

[c10] The system of claim 9, further comprising a display device for displaying the correlation.

[c11] The system of claim 9 or 10, wherein the second log data is acquired at a time later than the first log data.

[c12] The system of any of claims 9-11, wherein the logging sensor measures at least one parameter selected from the group consisting of gamma ray, resistivity, neutron porosity, density, ultrasonic caliper, and sigma.

[c13] The system of any of claims 9-12, wherein the logging sensor is disposed on an integrated measurement tool.

[c14] The system of any of claims 9-13, wherein the correlation is a depth correlation.

[c15] The system of any of claims 9-14, wherein the correlation is a time correlation.

[c16] The system of claim 9, further comprising a well log data processing system for calculating a relative effect using a sensitivity factor to adjust the correlation; and displaying the correlation and the relative effect on a display device.

[c17] A computer system for evaluating changes for a wellbore interval, comprising:

a processor;

a memory;

a storage device;

a computer display; and

software instructions stored in the memory for enabling the computer system under control of the processor, to perform:

gathering first log data from a logging sensor during a first pass over the wellbore interval;

gathering second log data from the logging sensor during a second pass over the wellbore interval;

calculating a plurality of delta values between the first log data and the second log data;

deriving an observed effect using the plurality of the delta values;

identifying a correlation between the observed effect and a causal event; and

displaying the correlation on the computer display.